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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/651,046	08/30/2000	PRADEEP K. SUBRAHMANYAN	S01.12-0632/SEA 9334	2354

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EXAMINER	
JONES, HUGH M	
ART UNIT	**PAPER NUMBER**
2128	

DATE MAILED: 07/12/2004 3

Please find below and/or attached an Office communication concerning this application or proceeding.

PTO-90C (Rev. 10/03)

PPe1

Office Action Summary	Application No. 09/651,046	Applicant(s) SUBRAHMANYAN, PRADEEP K.
	Examiner Hugh Jones	Art Unit 2128

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on 20/20/2001.

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) 1-8 is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) 1,2 and 5 is/are rejected.

7)☒ Claim(s) 3-4, 6-8 is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date 2, 4.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

DETAILED ACTION

1. Claims 1-8 of U. S. Application 09/651,046 are pending.

Drawings

2. Figure 1 should be designated by a legend such as --Prior Art-- because only that which is old is illustrated. See MPEP § 608.02(g). Corrected drawing sheets are required in reply to the Office action to avoid abandonment of the application. The replacement sheet(s) should be labeled "Replacement Sheet" in the page header (as per 37 CFR 1.84(c)) so as not to obstruct any portion of the drawing figures. If the changes are not accepted by the examiner, the applicant will be notified and informed of any required corrective action in the next Office action. The objection to the drawings will not be held in abeyance.

Claim Rejections - 35 USC § 103

3. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

4. The factual inquiries set forth in *Graham v. John Deere Co.*, 148 USPQ 459, that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.

2. Ascertaining the differences between the prior art and the claims at issue.

3. Resolving the level of ordinary skill in the pertinent art.

4. Considering objective evidence present in the application indicating obviousness or unobviousness.

5. Claims 1-2 are rejected under 35 U.S.C. 103(a) as being unpatentable over Kim et al. in view of Brown et al. or Lee.

Kim et al. disclose that in industrial motor drive systems, a shaft torsional vibration is often generated when a motor and a load are connected with a flexible shaft. This paper treats the vibration suppression control of such a system. In this paper, a control system design method using linear matrix inequality (LMI), which is a tool for control design that replaces or complements Lyapunov-Riccati equations, is provided and the H_∞ speed controller for an induction motor by LMI is proposed. In the H_∞ speed controller, weights are used to satisfy tracking and disturbance rejection. Experimental results show the validity of the proposed H_∞ speed controller by LMI, and this controller is compared with the state feedback controller. In particular, Kim et al. disclose use of the Riccati solutions to the reduction of vibration in disc drives including inertial matrices (sections 2-4) for internal disturbances.

Kim et al. do not appear to disclose taking into account “external” disturbances in addition to the internal disturbances.

Brown et al. disclose external as well as internal disurbances to motor drives. Environmental factors such as seismic **vibration** and temperature change, which

indirectly contribute to servowriting errors, are identified, and steps to contain these error sources are described. See section 2-3 on page 414.

Lee disclose an H^∞ model matching algorithm which is proposed for the robust motor tracking control of linear time-varying multi-input, single-output uncertain system. This control method is verified by the system of the permanent magnet DC motor to improve the drive performance and reduce sensitivity of parameter variations, nonlinear effects, and other disturbances such as load changes and backlash. The matching model is used to identify the H^∞ tuning controller with bounded noise energy and minimized tracking error. An algorithm based on discrete Ricatti equation and H^∞ interpolation theory is used to solve the uncertain internal modeling and noise measurement issues in the tracking control system. The adaptive tuning controller effectively controls the presence of **external disturbances**, and identifies the rapid jumping and slow changing trajectory of the system.

It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the Kim teaching with the Brown teaching because Brown teaches that external disturbances affect servowriting (col. 2, page 414).

It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the Lee teaching with the Lee teaching because Lee teaches that external disturbances affect rotor behavior (abstract and section I).

6. Claim 5 is rejected under 35 U.S.C. 103(a) as being unpatentable over Kim et al. in view of Brown et al. and in further view of (Reif et al. or Shah et al.).

Kim et al. is silent on whether the state estimator is a Kalman filter.

Reif et al. disclose an observer for continuous-time nonlinear systems. The observer gain is computed by a **Riccati** differential equation similar to the extended

Kalman filter. They prove that under certain conditions the proposed observer is an exponential observer by choosing an appropriate Lyapunov function. Furthermore, the authors explore some important relations of the proposed observer to robust control theory and H_∞-filtering. To examine the practical usefulness of the proposed observer they applied it to an induction motor for the estimation of the **rotor** flux and the angular velocity.

Shah et al. disclose a combined Kalman filter/Riccati approach to state estimation of non-linear systems.

It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the Kim teaching with the Reif et al. teaching because Reif et al. teaches that use of the Kalman filter approach is known in the art (col. 1, page 203) and that they extend and improve the Kalman filter approach (col. 1, page 203).

It would have been obvious to one of ordinary skill in the art at the time of the invention to modify the Kim teaching with the Shah et al. teaching because Shah et al. teaches that the use of a combined Kalman filter/Riccati approach (col. 3, line 11 to col. 4, line 46 in the context of state estimation, was known in the art.

Allowable Subject Matter

7. Claims 3-4, 6-8 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. The novel material relates to the particular

form of the covariance matrix which is calculated from the filter algebraic Riccati equation.

Conclusion

8. The prior art made of record and not relied upon is considered pertinent to applicant's disclosure:

Kim (dissertation abstract) discloses As the modern rotor systems have a tendency of being operated at high speed and designed to be lighter, the control of excessive vibration becomes more and more important because of increasing requirement in accuracy and reliability. Since the flexible rotor bearing system is a typical hyperbolic type distributed parameter system, the control, passive or active, not accounting for such a nature often does not yield satisfactory performance. The primary objective of this study is to develop efficient control design methods which account for and use the distributed parameter and isotropic properties. The output feedback control scheme accounts for the practical aspects such as the observation and related stability problems caused by spillover effects, while the optimal design deals mainly with the theoretical and numerical aspects. Optimal pole assignment in distributed parameter control systems is established and the existence of optimal solution is proven in case of compact linear feedback. The method, an extension of the finite dimensional design, gives the solution of the operator Riccati equation, which is known to be one of the most difficult problems faced by the designers. By adopting the complex notation for the isotropic systems, it is shown that the closed loop eigenstructure is determined, contrary to the real field design, so as to preserve the isotropic property. In order to utilize the

symmetric property between the two directional vibrations: vertical and horizontal or forward and backward, a new control scheme is designed by introducing the complex state for the systems having the isotropic property. The algebraic relations concerning distribution of the eigenvalues of complex matrices are developed so as to cluster the poles into specified regions, rather than fixed positions, imposing the relative stability margin, e.g.. uniform damping or uniform damping ratio. The closed loop eigenstructure has the direct one-to-one relation with the physical parameters and the isotropic property is preserved under feedback control. The method transforms Riccati equation to Lyapunov equation of the same dimension so that computational effort is almost removed. It is shown that the method can be used effectively in vibration control of rotating machinery such as the isotropic rotor bearing system, the magnetic bearing system and the rotating circular disk. To achieve the dual objective of stabilization and spillover suppression, a constrained output feedback control scheme is developed based on the optimization of a modified performance index which includes spillover terms. In order to construct the appropriate performance index, the method makes use of the two-time scale property of the primary and secondary modes. The control model is constructed based on the singularly perturbed modal model, which retains the simple modal structure while preserving the accuracy of the frequency domain modeling. A set of optimality condition is derived and iterative solution procedure is also presented. A set of simulation examples show the effectiveness of the proposed scheme. In order to control the rotation related periodic disturbances, a disturbance accommodating controller is also designed based on the disturbance estimator. The main advantage of

the proposed scheme is the simplicity in numerical calculation and estimator structures, requiring only a solution of non-symmetric Lyapunov equation of relatively small order. Lyapunov equation is the first order perturbation solution of the matrix cubic equation which yields the exact solution. Through the matrix perturbation analysis, it is proven that, for small gain, the approximate solution converges to the exact one. The control scheme is proven to effectively control the build up vibration subject to sudden imbalance through the numerical simulational. Finally, the output feedback control experiment is performed by using a magnetic bearing when the rotor system is subject to external impulse and imbalance. The magnetic bearing with four magnets is manufactured and the analog design is transformed to the discretized form and implemented by using a 16 bit microcomputer. The control model is constructed by using the experimentally obtained modal parameters through a set of modal testings in complex coordinates. The proposed control scheme enables the rotor to run through the first critical speed without excessive vibration against the initial system unbalance. In order to verify the performance of the proposed control scheme, the results are compared with the numerical ones. It is shown that the experimental results are fairly well coincident with the predicted ones. In conclusion, through the extensive analysis and experiments, it is shown that the proposed controllers can be used effectively in practical implementation as well as in theoretical and numerical aspect of controller design for the rotor bearing systems.

9. Any inquiry concerning this communication or earlier communications from the examiner should be:

directed to: Dr. Hugh Jones telephone number (703) 305-0023, Monday-Thursday 0830 to 0700 ET, ***or*** the examiner's supervisor, Kevin Teska, telephone number (703) 305-9704. Any inquiry of a general nature or relating to the status of this application should be directed to the Group receptionist, telephone number (703) 305-3900.

mailed to: Commissioner of Patents and Trademarks
Washington, D.C. 20231

or faxed to: (703) 308-9051 (for formal communications intended for entry) ***or***
(703) 308-1396 (for informal or draft communications, please label "*PROPOSED*" or "*DRAFT*").

Dr. Hugh Jones
Primary Patent Examiner
July 5, 2004

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